Montana State University Computer Science Department

Graduating Senior Exam

Fall Semester 2021, 80 minutes.

Your performance helps us assess how well we are meeting our stated learning outcomes for computer science majors. To pass this exam, spend at least 45 minutes in order to provide a carefully reasoned answer to each question. This information will help us make improvements.

Name Nathan Patera

Question 1: A company uses a ticket system for customer service. Each ticket is given an urgency score when it is entered into the system. For example, a VIP customer would receive a higher urgency score than a regular customer. Assume that the urgency scores range from 1 to 10,000. The company's customer service team needs a way to find the most urgent ticket in the system and remove it when it has been addressed. New tickets can arrive at any time.

a) What simple data structure would best model this situation? Explain.

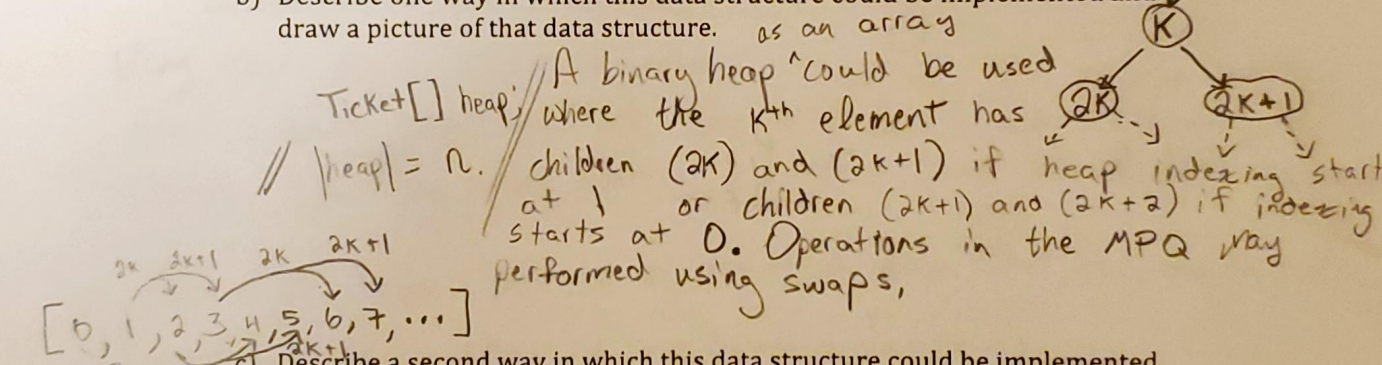
Maximum Priority Queue - One could implement as a binary heap in $O(n)$ space where inserts work in $O(\lg(n))$ as well as deletions. The most urgent item is always available at the top of the queue after every operation

b) Describe one way in which this data structure could be implemented and draw a picture of that data structure.

as an array

Ticket[] heap; // |heap| = n.

A binary heap could be used where the k^{th} element has children $(2k)$ and $(2k+1)$ if heap indexing start at 1 or children $(2k+1)$ and $(2k+2)$ if indexing starts at 0. Operations in the MPQ may performed using swaps,



c) Describe a second way in which this data structure could be implemented and draw a picture of that data structure.

Another way it could be implemented is building a tree by reference using objects rather than by using an array. Pointers keep track of children L, R and parent P. Operations done by trading references of that reference with pointers to itself.



Question 2: Write a function in a language of your choice that has two parameters: a string and a character. The function should return the number of times that the character occurs in the string.

Your language of choice (e.g. Python): C

Your solution:

```
int count(char* string, char ch){
    int count = 0;
    int i = 0;

    while (string[i] != '\0'){
        if (string[i++]==ch) count++;
    }
    return count;

}
```

Question 3: Consider a singly linked list that contains **n** floating point numbers and is maintained in ascending order. An additional **k** floating point numbers will be added to the list, one at a time. You may assume that **k << n**.

Best case time complexity of algorithm:

$\Omega(K)$

Explanation of best case time complexity:

Assuming the ordering of the K insertions is being entered in descending order and the first one entered (say K_0) is less than the first item in the singly-linked list than insertions are placed immeadilely.

$L = [6 \to 7 \to 8 \to 9 \to 10]$,

Say $K = [5, 4, 3, 2, 1]$,

Hence exactly K reads to insert...

step 1: $5 \to 6 \to 7 \to \cdots$

step 2: $4 \to 5 \to 6 \cdots$

step 3: $3 \to 4 \to 5 \to \cdots$

etc for K steps

Worst case time complexity of algorithm:

$O(K(n+K))$

$O\left(\sum_{i=0}^{|K|-1}(n+i)\right)$

$n, n+1, n+2, n+3, n+4 \cdots n+(K-1)$

$= nK + \underbrace{(1 + \cdots K-1)}_{O(K)}$

Explanation of worst case time complexity:

The worse case scenario is when the insertions are always inserted at the end due to increasingly sized floating point values (greater than initial last value).

First n items need to be traversed, then $n+1, n+2$, etc to $n+(K-1)$

$T = \sum_{i=0}^{K-1} n+i = n + (n+1) + (n+2) + \cdots + (n+(K-1))$

$= nK + \underbrace{(1 + \cdots + K-1)}_{K^2} = nK + \frac{(K-1)(K)}{2} = nK + \frac{K^2 - K}{2}$

Traverses to $O(T)$

$= nK + \frac{K^2}{2} - \frac{K}{2}$

$= O(nK + K^2 - K) = O(nK + K^2) = O(K(n+K))$

Question 8: Describe your one-year plan following graduation. If you plan to work, list where you have applied (the company and the position) and mention whether you have received any offers. If you plan to go to graduate school [illegible]

Question 4: List any extracurricular community involvement (e.g. the Gallatin Valley Food Bank or coaching), extracurricular university involvement (e.g. Engineering Ambassadors, Swing Cats, AWC or ACM) or paid internships (e.g. Workiva intern or Undergraduate Course Assistant) that you were involved with during your time at MSU. For each activity, (1) **provide** the name of the organization, (2) **describe** briefly your main activities and (3) **estimate** the total number of hours you spent.

I did not participate in any E.C. activities,.. formally with any 3rd party

Organization	*Main Activities*	*Hours Spent (estimate)*

Question 5: IEEE P7003 defines the Algorithmic Bias Standard.

a) Describe briefly what algorithmic bias is.

The idea that a program implements their own subjective standard or heuristics, or relies on invalid/inconsistent/biased data that unfairly or disproportionately prefers a specific outcome or solution against proper fairness. Usually effects people being unfairly excluded or included in evaluation.

b) Provide a hypothetical example of how algorithmic bias could manifest itself in college admissions software.

A program that ranks applicants could have been implemented with a scoring function that overvalues GPA or SAT or another metric in determing admissability of a student. For instance it may not consider any other outstanding metric or info such as community service or hours volunteered or how many high school credits. Thus the algorithm would/may reject them unfairly.

Question 8: Describe your one-year plan following graduation. If you plan to work, list where you have applied (the company and the position) and mention whether you have received any offers. If you plan to go to graduate school, list where you have applied (the school and the area of study) and mention whether you have received any acceptances.

I have no current plan for any specific job, but I do hope to be accepted to MSU's graduate college of CS. for Fall Semester 2022, Although I'd prefer to join Spring, but I'm late to applying to that term.

Question 9: List any organized social activities that you were involved with during your time at MSU. For each activity, (1) **provide** the name of the organization, (2) **estimate** the total number of hours you spent.

Organization Name	*Hours Spent (estimate)*

Once again, None.

Question 6: In 2010 Oracle sued Google claiming copyright and patent infringement for 11,500 lines of Java API copied code. Google used this small subset of code from the JAVA API for their mobile platform operating system. Pick a side (Google or Oracle) to win this lawsuit and explain 3 possible impacts to the computing industry of this win.

Side you choose to win: Google

First possible impact: Set a precedent for stealing copyrighted "intellectual property", allowing greater permissibility of it.

Second possible impact: Makes it more difficult (as precedent) for software developers to make useful code as the wheel needs to be re-invented over again.

Third possible impact: Makes it more difficult for the linux-community to develop code that is similar to copy-righted code, and slowing progress as more explicit-permission is needed

Question 7: In the ACM Code of Ethics and Professional Conduct, one ethical principle stated is to ***avoid harm***. Describe three different types of harm that the software of an autonomous, self-driving car might cause.

First type of harm: Physical - An improper decision by the software could cause an injury of passengers, other car's passengers, or hurt pedestrians

Second type of harm: Mental - It could influence slow or encourage a driver to take less caution in surveilling the appropriate operation of the car, causing eventual harm to others/self.

Third type of harm: less likely to handle erratic pedestrians or unexpected circumstances that puts everyone or them in harm's way.

Question 10: List any activities that you were involved with during your time at MSU that prepared you to work more effectively with teammates whose backgrounds are significantly different than your own. For each activity, (1) **describe** the activity and (2) **estimate** the total number of hours you spent.

Activity Description	*Hours Spent (estimate)*
EGEN - working with other fields to design RC-car	5 • 13 + 50 = 100 Hours
Tutoring - SmartyCats	200 Hours

Question 11: Name the most sophisticated version control system that you use and describe three nontrivial features it has.

Name of most sophisticated version control system: Git

Non-trivial feature 1: rebase - able to completely rewrite the past with a change that fixes an issue from along that was handled improperly.

Non-trivial feature 2: log - able to tell what kind of work that was going on-around a commit

Non-trivial feature 3: Diff - able to compare commit or file changes between any two commits

Question 12: During your time at MSU, list any major non-classroom, non-paid activities that you engaged in to help prepare for your computer science career. For example, you might have taught yourself a programming language or attended a workshop on a CS topic. For each activity, **estimate** the number of hours spent.

Activity Description	*Hours Spent (estimate)*
FFT - program that analyzes audio	100
IOT - temperature monitoring, controlled room lights, REST	300
Device Interfaces - gamecube/nintendo controllers, LCD screens	100

Best wishes wrapping up the semester and in the future!